Estimation of Spanish bunkering at EU level of secas

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Abstract— **On December 17 came into force on community standard marine fuels.The SOx emissions will be increased in the main shipping routes at a rate of 3 to 4% annually. Most of the sulphur burden will be attributed to shipping activity. Therefore the extension of SECAs could be beneficial towards the improvement of air quality.**

This paper begins with a review of the current situation SECAS and ECAS areas, highlighting the rules to be implemented shortly. The aim of the paper is known the current situation bunkering determine the estimated short term in Spain from economic variables

Keywords: Spanish bunkering, SECA, ECA, maritime transport

I. INTRODUCTION

The aim of this paper is to discuss the impact of a possible extension at European level of the Sulphur Emission Control Areas (SECA) as they are introduced in the Annex VI of the International Convention for the Prevention of Pollution From Ships, 1973 as modified by the Protocol of 1978 (MARPOL) adopted by the International Maritime Organisation (IMO). Air pollution attracts high political priority as it affects negatively public health and the quality of life. It is a complicated topic both scientifically and politically; conflicting interests of stakeholders are clashing, the scientific basis of their arguments or the rational differs, and potential actions might abate a pollutant yet contribute to the concentration of another. The issue on air pollution is primarily focused on the Green-House-Gases (GHG), primarily on Carbon Dioxide (CO_2) and non-GHG, such as the sulphur oxides (SOx), nitrogen oxides (NOx) and particulate matter. MARPOL Annex VI addresses primarily the issue of SOx, NOx and CO_2, among others.

As a result of the problems of increasing acidification by acid rain in northern Europe caused by air pollution and due to the contribution of emissions from ships, IMO has appointed the following two SECAs within the EU: Baltic Sea (effective May 2006), the North Sea and English Channel (effective November 2007). The standard EU limits described in Directive 1999/32/CE are less stringent than the limits in Annex VI of MARPOL. The note explores the risks associated with the expansion of the current SECA in the EU; this is valued including an introduction of new areas of sulphur oxide (SOx) Emission Control, and perhaps even a SECA expansion along the entire coastline of the EU.

Air pollution is a sensitive issue as it affects the quality of life of many people and has a direct impact on their health. Most of the Europeans are living close to the coastline and all main ports are bordering or are part of large urban complexes. The environmental impact of maritime operations, such as navigation, loading and unloading of cargoes, ship-repair and shipbuilding activity, etc. involves the emission of SOx, nitrogen oxides (NOx) and particulate mater (of 2.5 or 10 nm). NOx emissions are related to nutrient overload in water bodies that leads to eutrophication, and the excess of nutrient nitrogen can be detrimental to marine ecosystems and generally to ecosystems with a fragile balance. SOx are related to public health issues, such as asthma, bronchitis and heart failure. NOx and SOx in combination might cause acid depositions that can be detrimental to the natural environment (lakes, rivers, soils, fauna and flora). SOx and NOx emissions at sea can exert an influence on vegetation and land-based objects many thousands of kilometres away [1].

The topic cannot be analysed thoroughly in few pages; many academic studies have identified controversial issues, conflicting interests and goals, as well as methodological issues that determine the outcome of an analysis. Nevertheless it should be highlighted that most studies focus on air pollution generally and not specifically on the sulphur issues. This note aims to summarize key issues and points discussed in leading studies as well as in significant policy documents and address the requirements of the tasks.

References and links to the sources are provided, however a degree of 'subjectivity' is inserted, as the requirements demand a degree of forecasting, which inevitably reflects biases and personal believes.

The issue of air pollution and particularly the abatement of SOx emissions from ships, became a strategic goal of the EU in

2002. The Directive 2005/33/EC of the European Parliament and of the Council regulates the sulphur content of marine fuel, came into force in 2005. This regulatory action is streamlined with Directive 1999/32/EC, which relates to a reduction in the sulphur content of certain liquid fuels; this Directive has set the first sulphur limits for marine distillate oil used in EU territorial waters. Moreover, this directive extended the scope of the previous Directive 93/12/EC on the reduction of SOx emissions to cover certain liquid fuels derived from petroleum and used by seagoing ships. Recently, Directive 2005/33/EC extended the scope of Directive 1999/32/EC to all petroleum derived liquid fuels used by ships operating within Member States' waters. The above European regulatory actions aim to complete international rules and regulations agreed at the IMO and applicable to the world fleet practically. Furthermore, the issue of air pollution has ignited research interest as research and innovative rational approach should be taken into account in order to support actions, opinions and statements in international forums and debates.

Limiting the sulphur content of fuels has been a major concern among European shipping-responsible for 40% of the world fleet, the cost will involve the adequacy of the existing fleet to the new regulations, and therefore, its impact on freight.

II. LITERATURE REVIEW

The main technical reports addressing the issue of Green-House Gases (GHG) and of sulphur are the ones of European Marine Safety Agency (EMSA) of 2010 and of the Joint Research Centre –JRC- [1]. These reports offer the basis for publication of related work in the specialized academic journals. In the academic literature the interest lies on policy, modelling of economic policies as well as on operational issues, such as scheduling and performance. Generally the literature on GHG and air pollution is vast, yet there is no paper focused on the sulphur issues and its impact on shipping.

Substantial influence on the research and policy evolution is attributed to the studies of IMO on GHG (Buhaug et al., 2009), and of the EC (CE Delft and Germanischer Lloyd and MARINTEK and Det Norske Veritas, 2006; Faber et al., 2009), as well as independent position papers, such as that of the DNV [2], [3], [4]. The researchers contributed in the studies have also published their work in relevant academic journals, however the reports provide more comprehensive and integrated approach, and they are also freely available in the Internet. Generally, the work done on air pollution from ships aims to address policy issues, thus by nature more macro- than microeconomic ones; the impact of a regulation at a micro-level is not really discussed.

The interim report of the Seafarers International Research Centre (SIRC) offers an interesting insight on the effectiveness of international regulations on ships' sulphur emissions, based on observation of ship inspections in the UK and Sweden and on interviews with regulators, inspectors and industry stakeholders [5], [6]. As the UK and Sweden are coastal countries in the Northern European SECA, this reports sheds some light on compliance issues and lessons learned. Towards this direction, the report of [7] on the Baltic NECA and its economic impacts, although is not focused on sulphur emissions, is also helpful to understand both the options for policy makers as well as the risks faced by operators.

In the academic field, the contribution of [8] is notable; the first report on GHG emissions was published in 2008 [8]; the calculation of GHG emissions and the production of statistics on the basis of the world fleet data was the main result of this effort [9]. Outcomes of this report were presented also in the relevant academic press [10]. The focus of this research is primarily statistical. In his next contribution, he is examining the implication of the regulation, by discussing the opportunity cost and applying a logit-deduced modal split [11]. Finally, [12]discuss the issue of speed in container operations, elucidating the impact of air pollution regulation on logistics operations.

Another interesting set of contribution comes from the team of Miola et al. In the JRC study, [1] thoroughly discuss the issue of regulating air emissions from ships. Policy issues, and especially the design of climate change policy are given in [13]. Moreover, in [13], they present an analysis of modelling approaches and available data sources taking into account the findings of their 2010 report. Finally, interesting contributions in the field are those of [14], [15], [16]and [17], primarily focused on policy and environmental impact, as well as of [18], [19], [20] .

Almost all source above except the EMSA report of 2010, address issues related to GHG and air pollution in general. The issue of sulphur is marginally considered, as part of the MARPOL Annex VI regulatory pattern. Moreover, there is lack of academic work on the estimation of the financial impact of regulation in the shipping industry; interestingly enough, there is no publication related to other major regulatory changes, such as of OPA90 or ERICA packages. [21], [22] presented a primer on this issue in a peer-reviewed academic conference, and the full work is still under revision [22].

In reality, operators are confronted with shorter time frames related to their day-to-day business and in most cases they deal with uncertain market developments. Their problems are classed as 'fleet mix and management' problems; these problems aim to maximize profits (or to minimize costs), given budgetary, operational and other constraints. Environmental constraints have not been discussed widely yet. Recent contributions in the field, such as that of [23], discuss the reduction of emissions by optimizing speed in shipping routes. [24] published a work with similar focus yet with a more sophisticated formulation. Although the above-mentioned work is in many ways pioneering and the results stimulate academic work, it does not calculate the impact of the new environmental regulation to the operator.

III. INFORMATION ON MARPOL ANNEX VI

The International Maritime Organization (IMO) is a specialized Agency of the United Nations, and its mandate is principally concerned with marine technical and safety issues as well as with marine pollution and prevention of the environment from activity related to maritime transport. In 1973, IMO adopted the International Convention for the Prevention of Pollution from Ships, now known universally as MARPOL, which has been amended by the Protocols of 1978 and 1997 and kept updated with relevant amendments. The MARPOL Convention addresses pollution from ships by oil; by noxious liquid substances carried in bulk; harmful substances carried by sea in packaged form; sewage, garbage; and the prevention of air pollution from ships. MARPOL has greatly contributed to a significant decrease in pollution from international shipping and applies to 99% of the world's merchant tonnage.

The international maritime transport sector is a significant contributor to the Green House Gas (GHG) emissions, where CO_2 is the dominant polluter that attracts the interest of policy makers. From the data provided by the International Maritime Organisation (IMO), it is clear that transport activity is responsible for almost 27% of the total burden, and the large proportion of it is attributed to road transportation (≈80%). International shipping contributes only 2.7%, where ships burning marine diesel oil (MDO) and heavy fuel oil (HFO) are reportedly responsible for around 7% of global NOx emissions, around 4% of global sulphur dioxide emissions and 2% of global carbon dioxide emissions (International Maritime Organisation, 2009). The annex of this IMO document provides the full report on the updated 2000 study on greenhouse gas emissions from ships, entitled: Second IMO GHG Study 2009 [25]. The issue of emission reduction from ships is high in the political agenda. Stakeholders have expressed controversial arguments and scientists have identified methodological issues and raised concerns. The very first issue is the premonition of 'targeting' the maritime industry. Indeed, from the data provided by IMO and the study [25] it is clear that transport activity is responsible for almost 27% of the total burden, and the large proportion of it is attributed to road transportation. International shipping contributes only 2.7% of the total and aviation 1.9%, as it can be seen in Figure 1. Despite the relatively limited contribution, the marine industry has been affected disproportionally, if not targeted.

The above wording of 'disproportional impact' is considered in position papers of maritime interest, highlighting the fact that shipping is the most energy friendly mode of transport, when considered in unit terms. Reports, such as of the International Chamber of Shipping [26], highlight the comparison of the CO_2 emissions between different modes of transport. [1] reports also that "the World Shipping Council representing more that 60% of the global seaborne trade, takes the stand that the adoption of specific maritime emission caps would be inappropriate in the absence of a broader approach to regulation transportation emissions at the national and global level". In various sources, this stance is taken. The point is that shipping is in absolute terms a significant or substantial emitter, however it is the 'greener', in terms of energy consumption and environmental footprint.

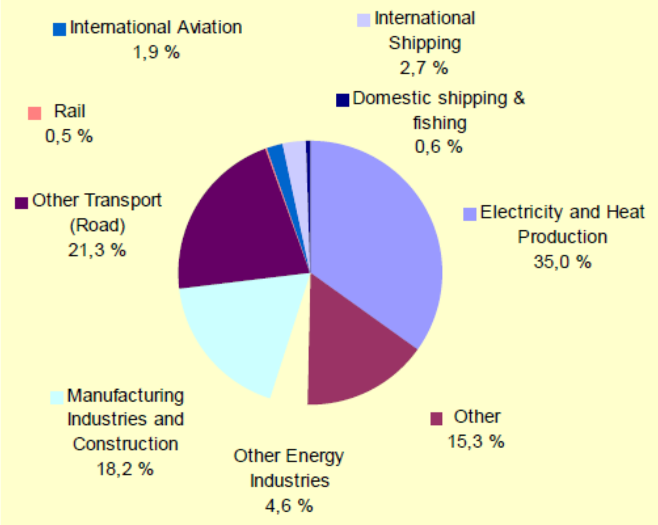

Figure 1. Emissions of CO_2 from shipping compared with global total

Apparently, shipping is a substantial emitter of non-GHG, such as of NOx and SOx, and regulatory action has been triggered. The new Annex VI of the international convention of MARPOL came into force on 19 May 2005, and a revised Annex VI with significant tighten emissions limits was adopted in October 2008 which entered into force on 1 July 2010.

More specifically, the main changes to MARPOL Annex VI are a progressive reduction globally in emissions of SOx, NOx and particulate matter and the introduction of emission control areas (ECAs) to reduce emissions of those air pollutants further in designated sea areas. Progressive reductions in NOx emissions from marine diesel engines installed on ships are also included, with a "Tier II" emission limit for engines installed on ships constructed on or after 1 January 2011 and prior to 1 January 2016; then with a more stringent "Tier III" emission limit for engines installed on ships constructed on or after 1 January 2016, operating in ECAs. Marine diesel engines installed on or after 1 January 1990 but prior to 1 January 2000 are required to comply with "Tier I" emission limits, if an approved method for that engine has been certified by an Administration. The revised NOx Technical Code 2008 includes a new chapter based on the agreed approach for regulation of existing (pre-2000) engines established in MARPOL Annex VI, provisions for a direct measurement and monitoring method, a certification procedure for existing engines, and test cycles to be applied to Tier II and Tier III engines. The control of diesel engine NOx emissions is achieved through the survey and certification requirements leading to the issue of an Engine International Air Pollution Prevention (EIAPP) Certificate and the subsequent demonstration of in service compliance in accordance with the requirements of the mandatory, regulations 13.8 and 5.3.2 respectively, NOx Technical Code 2008 (resolution MEPC.177(58)). Briefly stated, Regulation 13 of Annex VI, determines the following limits (figure 2):

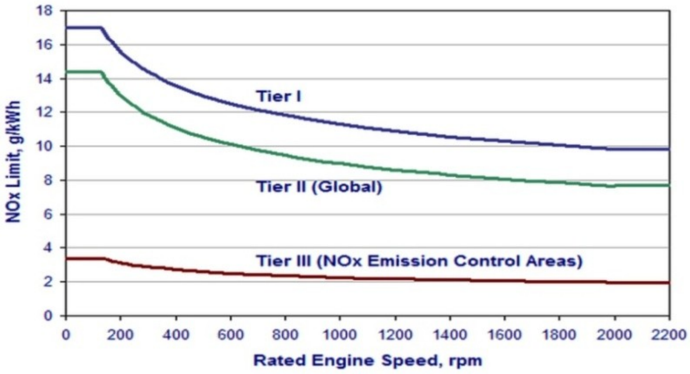

Figure 2. . Schematic representation of NOx reduction.

The Tier III controls apply only to the specified ships while operating in Emission Control Areas (ECA) established to limit NOx emissions outside such areas the Tier II controls apply. In accordance with regulation 13.5.2, certain small ships would not be required to install Tier III engines. The North American ECA came into force on 1 August 2011 and will take effect from the 1 August 2012. In July 2011, the 62nd session of the Marine Environment Protection Committee adopted the United States Caribbean Sea ECA, which is expected to enter into force on 1 January 2013, taking effect 12 months after (1 January 2014).

Regulation 14 of Annex VI is focused on the sulphur emissions (SOx). SOx and particulate matter emission controls apply to all fuel oil, as defined in regulation 2.9, combustion equipment and devices on-board and therefore include both main and all auxiliary engines together with items such boilers and inert gas generators. These controls divide between those applicable inside Emission Control Areas (ECA) established to limit the emission of SOx and particulate matter and those applicable outside such areas and are primarily achieved by limiting the maximum sulphur content of the fuel oils as loaded, bunkered, and subsequently used on-board. These fuel oil sulphur limits (expressed in terms of % m/m – that is by weight) are subject to a series of step changes over the years, regulations 14.1 and 14.4 (figure 3).

The ECA currently established are:

- • Baltic Sea area – as defined in Annex I of MARPOL (SOx only);
- • North Sea area – as defined in Annex V of MARPOL (SOx only);
- • North American area (expected to enter into effect 1 August 2012)
- • United States Caribbean Sea area (expected to enter into effect 1 January 2014)

At European Union level, certain rules on the sulphur content of marine fuel have been incorporated in the EU Directive 2005/33/EC amending Directive 1999/32/EC relating to a reduction in the sulphur content of certain liquid fuels and amending Directive 93/12/EEC.

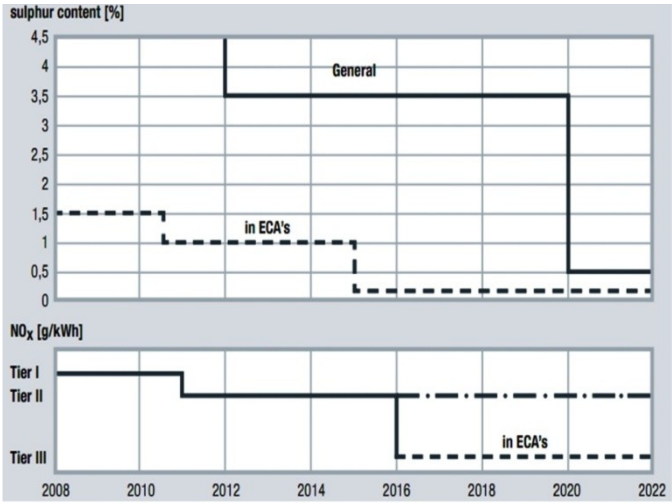

Figure 3. Schematic representation of SOx reduction

Revisions to the regulations for ozone-depleting substances, volatile organic compounds, shipboard incineration, reception facilities, and fuel oil quality have been made with regulations on fuel oil availability added. The revised measures are expected to have a significant beneficial impact on the atmospheric environment and on human health, particularly for those people living in port cities and coastal communities.

The bunkering in Spain is a mainstay of the economy and therefore must know the short-term estimates will be affected by this new policy to be implemented in the area ECAS and SECAS.

IV. METHODOLOGY

A. Searching the relationship

Searching the relationship among different economic indicators and tones of bunkering in Spain, different factors are used

- Spain GDP[1] per capita
- GNI[2] world
- GNI Developed Economies
- GNI Developing economies
- GDP world
- GDP Developed Economies
- GDP Developing economies
- OECD IPI[3]
- World fleet capacity in GT
- World fleet (number)

All the data use come from UNCTAD and the bunkering Data are obtained from Puertos del Estado (Spain) (table I).

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1 Gross domestic product
2 Gross national income
3 Industrial Production Index

TABLE I. GNI VS SPANISH BUNKERING

year	GNI-Developed-economies	Spanish Bunkering
2000	25085776.6736	553324
2001	24903461.5555	598470
2002	25874583.4098	632776
2003	29126633.8951	656509
2004	32431730.11	665326
2005	34134794.2188	714520
2006	36000133.2532	740160
2007	39185681.3937	765629
2008	41498766.8218	759499
2009	39007891.6202	762333
2010	40754649.3814	734329
2011	43731217.1062	814080

B. The model

To search the relationship between the factors can be used different regression models, regression analysis is a statistical process for estimating the relationships among variables. It includes many techniques for modeling and analyzing several variables, when the focus is on the relationship between a dependent variable and one or more independent variables. Here we have bunkering and economic indicators. Regression analysis helps one understand how the typical value of the dependent variable (or 'Criterion Variable') changes when any one of the independent variables is varied, while the other independent variables are held fixed: linear, quadratic, exponential and logaritmic

C. Selecting the model

The coefficient of determination, denoted R^2, indicates how well data points fit a line or curve. It is a statistic used in the context of statistical models whose main purpose is either the prediction of future outcomes or the testing ofhypotheses, on the basis of other related information. It provides a measure of how well observed outcomes are replicated by the model, as the proportion of total variation of outcomes explained by the model.

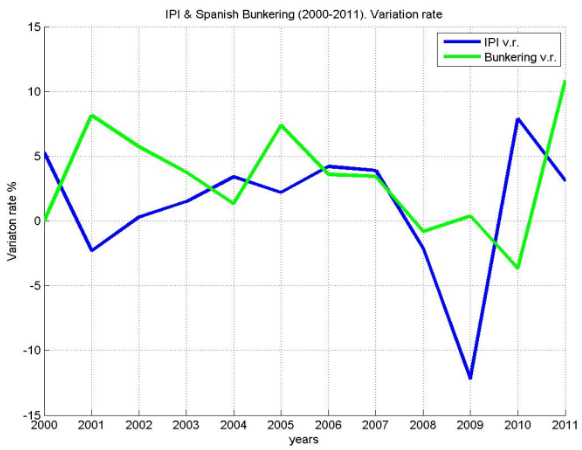

Figure 4. Variation rate %: *IPI vs. Spanish Bunkering*

In this way we compare the different models with R^2 and we select the nearest to 1(Figure 5), ejample figure 4.

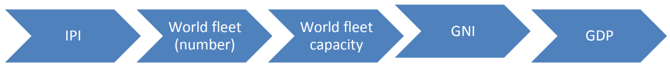

Figure 5. Factors vs. Spanish bunkering: *lower* - *higher* correlation coefficient

The highest correlation coefficient is: GDP vs. Spanish Bunkering (Figure 5).

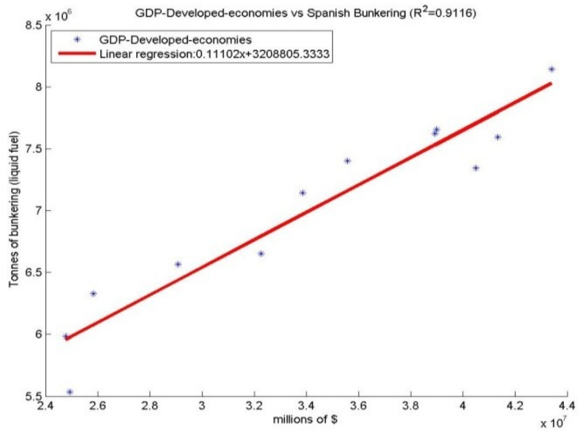

Figure 6. GDP vs. Spanish bunkering: correlation coefficient

D. Using the model: obtaining estimations

Using relationship estimated and IMF estimations we can calculate the bunkering estimated values in future (example table II).

TABLE II. STIMATION GDP-VS SPANISH BUNKERING

year	IMF	IMF	Estimation
2012	0	43121171.6664	7996173.8608
2013	1.2	43638625.7264	8053622.2831
2014	2	44511398.2409	8150518.6221
2015	2.5	44751410.6824	8177165.1154

V. CONCLUSIONS

The highest correlation coefficient is produced by the Spanish bunkering vs GDP ratio (figure 4). We know the forecasts of GDP in the coming years, so we can estimate the short-term Spanish bunkering (figure 7), to coincide with the years of implanting of new policies on the SECAS and ECAS areas.

Maritime traffic around Europe will definitely increase. This result is critical for many reasons: firstly SOx emissions are concentrated close to city-ports and the coast, where most of the population leaves, thus growing trade volumes and traffic suggest more severe negative impact to the littoral regions. Secondly, because it contributes adversely to wider air pollution issues, such as the ozone levels. Thirdly, because it implies that any decision will directly affect a higher number of ships, and indirectly the trade or the logistic chains they serve.

To facilitate this transition, the European Union has financing transport systems programs as Trans-European

Transport Network (TEN-T) and Marco Polo II program. These lines of community grant support initiatives related to improving environmental conditions through the development of new technologies, provide facilities for alternative fuels enter, such as LNG, and encourage the implementation of mechanisms that enable the use of electricity for conducting maneuvers approaching port.

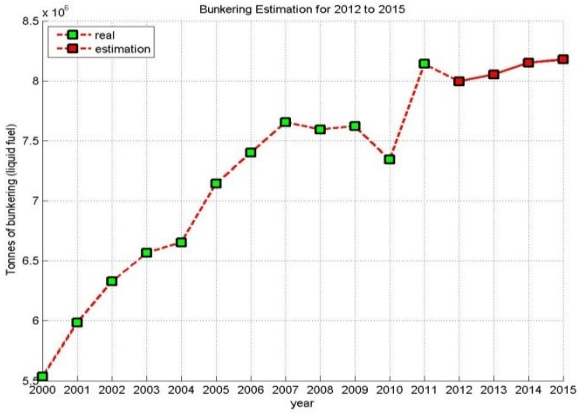

Figure 7. Spanish Bunkering estimation for 2012 to 2015

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